

BIGHORN SHEEP MANAGEMENT PLAN:
SOUTH BRISTOL MOUNTAINS MANAGEMENT UNIT*

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INTRODUCTION

In 1986, Assembly Bill (AB) 3117 (Mountjoy) was enacted by the California Legislature. That legislation amended Section 4700, and added Sections 4900-4905, to the California Fish and Game Code (Code). The legislature declared that the bighorn sheep is an important wildlife resource in California, and is to be managed and maintained at sound population levels. It also directed the Department of Fish and Game to prepare a management plan for each population (herd) of bighorn sheep in California. In addition, it authorized, for the first time in 108 years, very limited and carefully regulated harvest of mature male bighorn sheep.

In 1991, AB 977 was enacted by the legislature, and expanded the hunting program. In accordance with that legislation, it is the policy of the Department of Fish and Game to (1) maintain, improve, and expand bighorn habitat where feasible; (2) reestablish populations of bighorn sheep on historic ranges where feasible; (3) increase bighorn populations to levels such that no subspecies nor distinct population segment requires classification as threatened or endangered; and (4) encourage and provide for esthetic, educational, and recreational uses of bighorn sheep, as appropriate.

Overall statewide management goals and recommended actions are discussed in detail in the current management plan for bighorn sheep (California Department of Fish and Game 1983). This management plan has been prepared specifically for the South Bristol Mountains Bighorn Sheep Management Unit. It is intended to comply with legislative policy as set forth in Section 1801 of the California Fish and Game Code, and Sections 4900-4905 of the Code that, among other things, mandate that management plans be prepared for each bighorn sheep management unit, and that those plans provide information on (1) the numbers, age, sex ratios, and distribution of bighorn sheep within the management unit; (2) range conditions and a report on the competition that may exist as a result of human, livestock, wild burro, or any other mammal encroachment; (3) the need to relocate or reestablish bighorn populations; (4) the prevalence of disease or parasites within the population; and (5) recommendations for achieving the policy objective of Section 4900, which addresses the potential for limited hunting opportunities for bighorn sheep.

LOCATION

The Bristol Mountains are a large mountain range located in the central Mojave Desert, San Bernardino County. The range extends for approximately 65 kilometers in a northwest to southeast direction, and lies between the Cady Mountains on the west and the Soda Mountains and Granite Mountains on the east. The Bristol Mountains were bisected on an east-west axis by the construction of Interstate Highway 40 in the early 1970s; what is referred to as the South Bristol Mountains is the dominant geological feature within the South Bristol Mountains Management Unit. The management unit is centered approximately 110 km east of the city of Barstow, San Bernardino County, and is bounded on the south by the National Trails Highway (U.S. Highway 66), on the east by Kelbaker Road, and on the north by Interstate Highway 40; the western terminus of the triangular management unit is the junction of Interstate Highway 40 and U.S. Highway 66 at Ludlow, California (Figure 1). Other prominent

geological features within the management unit include the Lava Hills and an area known as Black Ridge, both of which are west of the South Bristol Mountains, and the Brown Buttes, located in the northeastern portion of the Management Unit.

HABITAT DESCRIPTION

Elevations on the South Bristol Mountains Management Unit range from approximately 200 m just southwest of Amboy in the southern portion of the unit to nearly 1000 m at the highest point in the northeast part of the range, just south of Interstate Highway 40. Geologically, the South Bristol Mountains are composed of remnants of Proterozoic plutons, metamorphosed Paleozoic passive margin rocks, Jurassic hypabyssal and plutonic rocks, and Neogene volcanic and sedimentary sequences (Harvey 2010).

Weather conditions in this management unit are typical of the Mojave Desert. Daytime high temperatures in summer frequently exceed 38°C, and temperatures below freezing in winter are not uncommon (Weaver et al. 1969). Precipitation in the vicinity of the management unit averages 10 cm annually, with about half of it falling as summer showers (Freiwald 1984) that are extremely localized throughout the Mojave Desert. As a result, annual precipitation can vary considerably, even within the management unit.

Much of the South Bristol Mountains Management Unit is in public ownership, although some parcels of private land occur throughout that area. The majority of the private property in the management unit had been owned by the Catellus Development Corporation, but much of that has been acquired by the federal government and is now administered by the U.S. Bureau of Land Management (Railroads and Clearcuts 2010).

Vegetation

Habitats within the management unit are typical of the Mojave Desert, and consist largely of desert scrub and desert wash (Mayer and Laudenslayer 1988). Creosotebush (*Larrea tridentata*) is the dominant species within the desert scrub community, and smoke tree (*Psoralea argemone*) is a dominant species within desert wash habitats (Paysen et al. 1980).

Water

Water is extremely limited within this desert management unit. Water is available for wildlife at Miller's Cabin Spring, located in the South Bristol Mountains in the eastern portion of the management unit, and which was developed decades ago by unknown parties. In 2008, a water development was constructed at the Amboy Limestone Quarry on property owned by the Omya Corporation in a cooperative effort with the Society for the Conservation of Bighorn Sheep. These water sources are utilized heavily by bighorn sheep, and are the only permanent sources of water known to exist in the management unit.

RANGE CONDITIONS

Range conditions in the Mojave Desert are quite variable from year to year, season to season, and area to area, and are a function of the timing and amount of

annual rainfall (Noy-Meir 1973). Thus, forage availability can be quite variable both within and among years, and even within the management unit.

Livestock

No livestock grazing permitted by the Bureau of Land Management is known to have occurred within the South Bristol Mountains Management Unit, but cattle from the Colton Hills and Granite Mountains allotments north of Interstate Highway 40 historically utilized the Marble Mountains and Clipper Mountains. Those ranges lie immediately east of the South Bristol Mountains and it is possible that cattle occasionally ranged into the management unit, particularly prior to the construction of Interstate Highway 40. No livestock grazing currently is permitted in the management unit.

Feral Animals

Feral donkeys (*Equus asinus*) occupied the nearby Marble Mountains and Clipper Mountains until the early 1980s, and it is probable that donkeys occasionally ranged westward into the South Bristol Mountains from those ranges. Indeed, Weaver et al. (1968) indicated that the northern end of the management unit was within the distributional range of feral donkeys. Over the last 30 years, however, no donkeys are known to have occupied the South Bristol Mountains and it is thought that none currently inhabit the management unit.

Habitat Improvements

Surface water is available for use by wildlife at two locations in the South Bristol Mountains Management Unit. One location, Miller's Cabin Spring, presumably has provided a dependable source of water for many decades and, as a result of recent improvements carried out by the Society for the Conservation of Bighorn Sheep (SCBS), continues to do so. The water development consists of a pickup pipe buried at the source of the spring, and an above-ground plastic tank that stores 7,000 liters of water; overflow from the tank seeps back into the ground. A second source of surface water has been developed by SCBS south of Miller's Cabin Spring on property owned by the Omya Corporation. That water source consists of an above-ground plastic tank that stores 7,000 liters of water, and is filled by storm runoff, and can be supplemented with water transported to the site by vehicle. Both of these water sources are used extensively by bighorn sheep. Currently, 100% of the maintenance necessary to ensure the functionality of these wildlife water developments is accomplished by personnel affiliated with the Society for the Conservation of Bighorn Sheep.

The potential location of an additional wildlife water development has been identified approximately 7 km northwest of Miller's Cabin Spring and approximately 2.5 km southwest of the Orange Blossom Mine. The potential benefits of that development were recognized in 2001, but no action has yet been taken to develop that source. That water development was proposed to help offset any impacts to the population of bighorn sheep that could result from an unanticipated disruption of water availability at Miller's Cabin Spring, as the new development would provide an additional source of water in the north end of the South Bristol Mountains. The proposed water development would likely encourage an expansion of bighorn sheep into habitat that has been occupied, at best, on a seasonal basis in recent decades. Any bighorn sheep that historically

occupied the South Bristol Mountains likely had access to numerous water sources in the Granite Mountains, such as Budweiser Spring, located approximately 10 km from the proposed development, but that no longer are available to this population because opportunities for movement between the South Bristol Mountains and Granite Mountains have been severely compromised. Construction of this additional wildlife water development would help offset the impacts of the construction of Interstate Highway 40, albeit some 40 years later.

Other Human Influences

Construction of Interstate Highway 40 in the early 1970s restricted any movements between the Granite Mountains and the South Bristol Mountains that may historically have occurred. Movement corridors between mountain ranges are important components of bighorn habitat (Schwartz, et al. 1986; Bleich et al. 1990, 1996; Epps et al. 2007). Unfortunately, the interstate highway already exists and, as a result, genetic interchange with populations of bighorn sheep to the north of the South Bristol Mountains likely is very limited (Epps et al. 2005).

The Orange Blossom Mine, located in the northern end of the South Bristol Mountains, was in production from 1900 until 1910, but mining activity has not occurred during recent times (Vredenburg et al. 1981). Currently, the Omya Corporation operates the Amboy Limestone Quarry, located 10 kilometers east of Amboy in the southern end of the South Bristol Mountains. The Amboy limestone deposit, a very high purity, high brightness crystalline deposit, is of such high purity that it is suitable for pharmaceutical and food grade limestone applications, and can be utilized in products for human consumption. The current mine life is projected to be 55 years plus reclamation phases, for a total operational life of 70 years. The current quarry development occurs in an area of about 10 acres; the quarry ultimately will cover approximately 50 acres (Brown 2003). There are no recognized impacts to bighorn sheep associated with the Amboy Limestone Quarry.

A gas pipeline runs in an east-west direction just south of Interstate Highway 40 for much of the length of the management unit, and the pipeline receives regular security patrols on the road that parallels the pipeline. The Atchison, Topeka, and Santa Fe Railroad tracks run approximately parallel to the National Trails Highway through the south end of the management unit. Neither the pipeline road nor the railroad tracks present barriers to movement by bighorn sheep. A communications tower and associated infrastructure, including a lengthy access road, recently have been constructed along Interstate Highway 40 near the crest of the range, but those facilities have not been demonstrated to be problematic for bighorn sheep. The town of Amboy is located in the extreme southern part of the management unit, but is sparsely inhabited and presents no recognized problems for bighorn sheep.

Limited hunting, primarily for Gambel's quail (*Callipepla gambelii*) or a variety of predators, currently occurs in the management unit. Limited recreational rockhounding also occurs there. All of these activities are compatible with the existing population of bighorn sheep. Vehicular access is limited to existing roads and trails by the Bureau of Land Management. Currently, there is no evidence that human infrastructure or use of

the area present obstacles to the persistence of bighorn sheep within the management unit.

THE BIGHORN POPULATION DISTRIBUTION AND HABITS

Although it has not been ascertained, it is probable that bighorn sheep historically occupied the South Bristol Mountains, at least on a seasonal or transient basis. According to a map included in Weaver et al. (1968), those investigators did not ascribe any population of bighorn sheep specifically to the South Bristol Mountains; instead, Weaver et al. (1968) indicated that the South Bristol Mountains were within the potential seasonal distribution of bighorn sheep that comprised several nearby populations in the eastern Mojave Desert. The proximity of the management unit to the Bullion Mountains to the south, the Granite Mountains on the north, and the Marble Mountains to the east is consistent with the historical potential for seasonal movement by bighorn sheep into, out of, or through the South Bristol Mountains. Moreover, prior to the construction of Interstate Highway 40 the South Bristol Mountains represented the southern end of the Bristol Mountains (now referred to as the North Bristol Mountains) and were contiguous with the North Bristol Mountains. Evidence of bighorn sheep in the Bristol Mountains is present in the form of well-worn trails, indicating that bighorn sheep at one time were widespread in that range.

The population of bighorn sheep currently occupying the South Bristol Mountains could be the result of a colonization that occurred during the early 1990s (Bleich et al. 1996). As recently as 1994, no bighorn sheep were thought to occupy the South Bristol Mountains on a permanent basis (Torres et al. 1994, 1996). Three females are known to have traveled to the South Bristol Mountains from the nearby Marble Mountains beginning in 1993; initially only a single female was known to remain year-round, where she bore a lamb (Bleich et al. 1996) and was later joined by a second telemetered female, and possibly other uncollared females (Epps et al. 2010). It is possible that the population of bighorn sheep inhabiting the South Bristol Mountains represents the offspring of these few females (Epps et al. 2010).

Other observations suggest that male bighorn sheep occupied the South Bristol Mountains, at least on a seasonal basis, prior to 1993. Bighorn sheep occasionally occupy the Brown Buttes, and move between that landscape feature and the Marble Mountains. Unmarked bighorn sheep also may move between the South Bristol Mountains and the Marble Mountains. Moreover, at least two collared, but unidentified, bighorn sheep have been recorded in the Bullion Mountains, and there is informed speculation that those animals emigrated southward from the South Bristol Mountains. Further, an aerial observation of a collared, but unidentifiable, male bighorn sheep on 26 May 1994 suggested movement from either the Bullion Mountains or the Sheephole Mountains to the South Bristol Mountains. Additionally, observations of bighorn sheep moving northward from the Sheephole Mountains across Bristol Dry Lake toward the South Bristol Mountains "...many decades ago..." were described by Mr. Buster Burris (a life-long resident of Amboy, but now deceased) to V. C. Bleich in 1982. Such intermountain movements are critically important to maintaining metapopulation function and, hence, to the persistence of bighorn sheep in those mountain ranges (Schwartz et

al. 1986, Bleich et al. 1996, Epps et al. 2007). Movements by bighorn sheep across Interstate Highway 40, either to or from the North Bristol Mountains, have not yet been recorded, but an effort to detect movements by bighorn sheep through existing culverts and bridges along the highway has been initiated by personnel affiliated with the Society for the Conservation of Bighorn Sheep.

POPULATION DYNAMICS

Population Size and Trends

Prior to 1993, the history of bighorn sheep in the South Bristol Mountains is largely uncertain. Evidence suggests, however, that the current population stems, at least in part, from a colonization event that initially involved the movement of adult female bighorn sheep westward from the Marble Mountains (Epps et al. 2005, 2010). Indeed, records indicate that a visit by knowledgeable personnel to Miller's Cabin Spring in 1986 yielded no evidence of use of that site by bighorn sheep.

As of 1994, three of 10 female bighorn sheep collared previously in the Marble Mountains had made seasonal movements to the South Bristol Mountains as indicated by aerial and ground telemetry. During May 1994, a helicopter survey yielded observations of one adult female and her offspring, and 4 adult males. Structured helicopter surveys (Wehausen and Bleich 2007) have been conducted each year since 1999, and the population has shown a continued upward trend in the number of bighorn sheep observed annually (Table 1), but visibility bias is inherent in aerial surveys and almost always results in fewer sheep being counted than actually are present (Graham and Bell 1987). In 2007, application of a mark-resight estimator revealed that 68 bighorn sheep occupied the South Bristol Mountains (Epps et al. 2010). Aerial surveys conducted during 2009 and 2010 yielded observations of 83 and 72 bighorn sheep, respectively. Application of a very conservative visibility correction factor (0.80) indicated that a minimum of 104 and 90 adult and recruited young were present in the South Bristol Mountains during each of those years.

Population Structure

Aerial survey data indicate that recruitment of offspring into the population has been adequate to yield a strong, positive trend in the population. Yearling females are difficult to identify from the air, but among desert bighorn sheep Class I males generally are yearlings. Although survival rates of young male and female bighorn sheep may differ, observation rates of yearling male bighorn sheep in the management unit (Table 1) indicate generally high recruitment, and are consistent with the strongly positive trend in population size described previously.

The ratio of male to female bighorn sheep in the management unit is consistent with what would be expected in an unexploited population of polygynous ungulates. Structured aerial surveys (Wehausen and Bleich 2007) conducted since 1999 have yielded ratios ranging from 59 to 92 adult males per 100 females (mean = 79 ± 12 [sd]; Table 1).

Mortality Factors

Diseases and Parasites

Bighorn sheep were not captured in the South Bristol Mountains as part of the rangewide effort to determine disease prevalence among bighorn sheep in California (Clark et al. 1985). Nevertheless, blood samples were collected from 22 bighorn sheep captured in this management unit during 1997, 2002, and 2005. Evidence of disease exposure was remarkably low: one individual tested positive for leptospirosis, 10 had low titers for chlamydia, and 7 had low titers for contagious ecthyma. Contagious ecthyma was clinically evident among several animals handled in November 2005, but had not been detected among animals previously in that population. There is no evidence that any disease is limiting the population of bighorn sheep in the South Bristol Mountains.

Predation

Mountain lions occur in the Granite Mountains, immediately north of the management unit, where they have had some impact on survival of female bighorn sheep in that range (Wehausen 1986). A mountain lion recently was observed in the Marble Mountains, immediately east of the management unit, but there has been no indication that predation is a factor regulating the bighorn sheep population in this management unit.

Other Mortality Factors

Bighorn sheep have been killed occasionally by automobiles traveling along Interstate Highway 40, or on Kelbaker Road. Whether or not those mortalities represent animals that were seasonal or permanent residents of the South Bristol Mountains is unknown, but it is unlikely that these losses have had any appreciable affect on the dynamics of the population.

TRANSLOCATIONS

All available evidence (Table 1) indicates that the population of bighorn sheep inhabiting the South Bristol Mountains has increased continuously since female bighorn sheep were detected in that range in 1993. Prior to 1993, the Bristol Mountains had been identified as a location to which bighorn sheep should be translocated, and 21 bighorn sheep (15 ewes and 6 rams) were released in the North Bristol Mountains in 1992. Currently, there is neither a need nor any intent to translocate bighorn sheep to the South Bristol Mountains. If the population continues to increase it could, however, be considered as a source of animals for translocation to other suitable areas formerly occupied by bighorn sheep.

RECOMMENDATIONS FOR ACHIEVING MANAGEMENT GOALS

Section 4900 of the Fish and Game Code declares it ... "to be the policy of the state to encourage the preservation, restoration, utilization, and management of California's bighorn sheep population," and that "management shall be in accordance with the policy set forth in Section 1801" (of the Fish and Game Code). To fulfill that policy and to achieve management goals for bighorn sheep in the South Bristol Mountains Management Unit, the following recommendations are provided.

1. This bighorn population should continue to be monitored carefully. Aerial surveys have been conducted in autumn each year since 1999 to develop information on population size and trends, structure, and rate of recruitment into the population. These surveys have been structured appropriately in that the same areas are flown at the same intensities in order to derive meaningful estimates of catch per unit effort, and to maximize opportunities to detect changes in population trends (Wehausen and Bleich 2007). An effort should be made to develop a model that will be useful in projecting population size forward (Conner 2009, 2010) prior to conducting additional annual surveys. Following development of that model, additional aerial survey data will be necessary to validate and fine-tune any resulting model.
2. It is probable that at least 50 female bighorn sheep currently occupy the management unit, and every effort should be made to maintain that number, recognizing that the timing and amount of rainfall will play an important role in the dynamics of this population.
3. Every effort should be made to maintain a minimum ram:ewe ratio of 50:100 in this population if animals are removed for translocation or by harvest.
4. This population of bighorn sheep is remarkably free of evidence of past exposure to disease(s). Nevertheless, whenever bighorns are captured in this management unit, appropriate samples should be collected for serological and other examinations to monitor incidence of diseases, parasites and, to the extent possible, changes in rates of infection. These results should be examined in the context of the status, condition, and productivity of the bighorn sheep population.
5. The 2 existing water sources likely have played an important role in the growth and persistence of this population. These water sources must continue to be inspected at least twice a year, and maintenance necessary to ensure availability of water must continue uninterrupted. In the absence of any Department of Fish and Game personnel assigned specifically to bighorn sheep habitat issues, all inspections and maintenance currently are conducted by individuals affiliated with the Society for the Conservation of Bighorn Sheep.
6. Because of the high level of interest in bighorn sheep, every effort should be made to keep the public informed of the status of this population, as well as management goals and activities. Information can be disseminated through the Department's public information officers, news releases, popular and technical articles, the Department's web site, or other appropriate methods.
7. The Department should expand its cooperation with citizen groups that support and encourage sound management of bighorn sheep. The Department should continue to request assistance from interested citizens to conduct inspections, repairs, or improvements to existing water sources, with installation of new water sources, or when conducting surveys necessary for management of bighorn sheep. The Department has had long-standing and successful relationships with several citizens groups dedicated to conservation of bighorn sheep and other

wildlife, including the Society for the Conservation of Bighorn Sheep, Desert Wildlife Unlimited, the Volunteer Desert Water and Wildlife Survey, and the California Chapter of the Wild Sheep Foundation. Continued participation of citizen groups is vital to successful management of bighorns in California.

8. The Department should reestablish the position of desert water coordinator to direct and oversee the activities of citizen groups interested in the conservation of bighorn sheep. The position has not existed for more than 5 years, and continued participation by citizen groups will be contingent upon the Department playing a leadership role with respect to volunteer activities.
9. In keeping with the overall policy of the California Department of Fish and Game, this population should be considered in the context of its potential to provide recreational uses, including opportunities to harvest a limited number of mature males.
10. To keep this management plan current, annual reviews should be prepared. Those reviews should include: (a) results of aerial and ground surveys, distributional data, and age and sex composition of the population; (b) results of any capture or translocation efforts; (c) a report of water conditions, including any maintenance or improvements performed; (d) a summary of recent disease and parasite findings; (e) a summary of any telemetry or other research findings; and (f) a summary of any habitat disturbances, poaching incidents, harassment, or other factors that might be detrimental to the population, along with recommendations for management actions to correct any such problems.

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Table 1: Results of bighorn sheep aerial surveys conducted in the South Bristol Mountains, San Bernardino County, California, 1994 - 2010

Date	Effort (Hours)	Lambs	Ewes	Yearling Ewes	Males				Total
					I	II	III	IV	
5/26/1994	2.5	1	1	0	0	2	1	1	6
9/28/1999	*	3	5	0	0	0	1	0	9
10/19/2000	0.7	2	6	0	1	0	3	0	12
10/1/2001	1.7	10	11	1	4	2	5	0	33
9/25/2002	1.8	6	9	3	4	5	1	1	29
9/30/2004	1.8	13	21	0	3	5	3	6	51
10/4/2004	1.6	6	20	0	6	3	3	2	40
10/11/2005	1.9	11	20	0	2	2	11	0	46
10/2/2006	2.2	5	29	0	5	6	9	5	59
10/17/2007	2.4	6	21	0	4	2	7	3	43
10/6/2009	2.3	13	44	0	5	3	9	9	83
10/6/2010	2	9	33	0	3	12	10	5	72

* Flight time was not recorded because the purpose of the flight was to locate specific collared animals.

